THE STIMULUS OF WAR TO CARDIOLOGY*

A Review

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IN modern warfare, infectious diseases and injuries requiring surgical care are the chief concerns of the medical departments of the Armed Forces. Cardiovascular disorders among those on active duty have occupied a position of lesser importance, largely because Selective Service and pre-induction examinations have eliminated those recruits manifestly unfit because of such defects. Yet much information has been gained concerning the incidence and types of heart diseases among the population as a whole; and studies in special fields have yielded knowledge not restricted to the conditions of war. In this brief summary are reviewed only a few of the numerous investigations which have been made. Indeed, the results of many of them have not yet been published. The remarks which follow will be confined to a consideration of some of the clinical problems relating to cardiac disease in the Army, which present features of equal interest in civilian practice.

HISTORICAL NOTE

It is doubtful whether it would be profitable to follow the heart of the soldier through all the campaigns of history; it is certainly not practicable because the necessary data are lacking. But some of the observations recorded during the past hundred years serve to reflect the changing points of view during this period. R. H. Hunter,[1] stationed in India, writes in 1836: "Ever since I joined the 2d or Queen's Royal Regiment in Colaba in 1831, I have been struck with the frequency of cardiac and aortic disease.... Whether, or not, rheumatism be the first link in the morbid chain, a more efficient cause for hastening its progress,

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I am convinced, is the active duty a soldier undergoes whilst buttoned up in his accoutrements. These, by compressing the neck and chest, obstruct the circulation to such a degree, as to excite the heart to inordinate action, and consequent hypertrophy in the strong and muscular, or to dilatation in the weak and sickly....

"It seems extraordinary that, now the effects of tight lacing on females are so well known, a soldier, intended for the most active and long continued exertion, should be placed in a similar predicament, when that very exertion is required. Is it possible he could be placed under more unfavorable circumstances?"

The role of tight clothing and heavy equipment as a cause of heart disease continued to occupy the attention of those in authority. In 1870, some thirty-four years later, Myers,[2] an assistant surgeon of the Coldstream Guards, won the Alexander Memorial Fund Prize for his essay, "On the Etiology and Prevalence of Diseases of the Heart Among Soldiers." The Executive Committee of the Fund, composed of distinguished physicians and high-ranking officers of the British Army, chose both the topic and the winner. The subject evidently was considered an important one.

Among Myers' conclusions were these: disease of the heart was more prevalent in the army than in the civil population; its three main causes were rheumatism, Bright's disease, and violent manual labor; syphilis, by attacking both classes to nearly the same extent, produced a relatively equal deteriorating effect; disease of the mitral was more common than disease of the aortic valve in the civil population, and aortic more than mitral in the army. In view of this higher incidence of aortic disease among the troops, the modern reader will wonder whether syphilis, after all, may not have exerted its "deteriorating effect" more frequently in the military man.

With regard to etiology, this author remarks: "there is one special cause of heart disease in our army now clearly laid down by those who have most studied the subject—viz., the prejudicial constriction of the uniform and accoutrements—this producing such obstruction to the circulation that, either directly or indirectly, as by aneurism and disease of the aortic coats, etc., the heart is abnormally strained, and frequently passes into a state of functional derangement, and ultimately of organic disease." Remedial measures were suggested and the opinion expressed that when these had been adopted, heart disease would gradually

diminish in the army.

In our own Civil War[3] organic disease of the heart was rare, only 3,778 cases having been taken to sick report on this account among the white troops during more than five years. But if discharges are taken into account, 10,636 men were lost to the service because of heart diseases. The difference between the two figures, says the official report, may be regarded as expressing the results of acute rheumatism, of which 145,551 cases were registered. This is a surprisingly large number.

The occurrence of idiopathic pericarditis was specifically mentioned and there were numerous instances of sudden death, attributed to "a relaxed or degenerated heart or to the development of fibrinous concretions within its cavities:" One instance of cardiac rupture, referred to as "phenomenal," occurred in a wounded man while confined to bed. Autopsy showed an adherent pericardium; there was no mention of the state of the coronary arteries or of the heart muscle.

The most important and enduring medical contribution to come out of the War of the Rebellion was the paper of Da Costa, "On the Irritable Heart: A Clinical Study of a Form of Functional Cardiac Disorder and Its Consequences," published in 1871.[4] Very little has been added to his description of the essential features of this condition, to which the terms effort syndrome and neurocirculatory asthenia later were applied. To this day, the basic mechanisms responsible for its manifestations are not clearly understood and furnish a subject for controversy.

World War I

Once again functional disorder of the heart, now labeled "effort syndrome," was the condition subjected to most intensive study. It was a cause of much invalidism and a frequent reason for discharge in both the British and American armies. Sir Thomas Lewis and his group at Colchester[5] made the most detailed observations. Lewis was aware that he was describing a series of symptoms which might occur under varying circumstances—as a result of exposure and strain, during delayed convalescence and in association with active infection, particularly tuberculosis. One of his largest groups was that of constitutional weakness, nervous or physical, or both. His critical analysis served to define and stress the various clinical features. He was of the opinion that many could be cured by a system of graduated exercises, and that, in a large number, the natural course was towards recovery. Grant's follow-up

study of 665 of Lewis's cases[6] showed that, in them, the frequency of pulmonary tuberculosis was 80 per cent greater than in the general population of London over the same five-year period. This high incidence was due, undoubtedly, to errors in diagnosis because routine x-rays of the chest were not made. Incipient cardiac disease was shown to be the underlying cause in only a negligible proportion of the patients.

The after histories of a thousand men discharged from the British Army because of valvular heart disease were also studied by Grant.[7] The patients were followed for ten years. Most of them had rheumatic valvular defects; a few had syphilitic aortic disease. Those with a good prognosis showed little or no cardiac enlargement and a good exercise tolerance. Those with a poor prognosis showed moderate or great enlargement and evidences of congestive failure. The onset of auricular fibrillation influenced the general prognosis unfavorably. Grant's final conclusion was to the effect that the outlook of valve defect was not as bad as generally thought, even for syphilitic aortic regurgitation.

Some figures of interest, in relation to those of World War II, are given in the official report of the Cardiovascular Section of the Office of the Surgeon General of the United States Army.[8] In one million recruits, 1.5 per cent were rejected for cardiovascular reasons; 0.88 per cent with cardiac disorders were accepted for limited service only. The causes of disqualification of 11,562 recruits so rejected were: chronic valvular disease, 49 per cent; other organic diseases, 19 per cent; functional disorders, 23 per cent. The belief was expressed that the number rejected for organic heart disease—68 per cent—was too large, due to the tendency on the part of the examiners to classify functional conditions, such as irritable hearts, as instances of organic disease.

In the German[9] and British[10] official medical reports of the first World War there were no features worthy of special mention with respect to the cardiovascular system. Most of the chapter in the British report was devoted to a consideration of the effort syndrome.

World War II

Neurocirculatory Asthenia. Because of the frequency, in the previous war, of the effort syndrome, or as it was now called, neurocirculatory asthenia, the importance of this condition was stressed as soon as the draft became effective. This was done in order to keep out of the

Armed Forces recruits suffering from the disorder and with the idea of learning more of its etiology. At first, cases of slight degree were accepted for service; later it became apparent that it was wise to reject even those with the mildest symptoms, for they made poor soldiers. The diagnosis, however, was not always easy. Fortunately, many of these cases were excluded as a result of the neuropsychiatric examination.

In England, Wood[11] began work in 1940 and in May 1941 read three Goulstonian lectures on "Da Costa's Syndrome (or Effort Syndrome)." His conclusions were based on a careful clinical study of two hundred cases. It was his opinion that the central stimulus was emotional and was commonly the result of fear; that this disorder should be classed as psychiatric; and that the somatic manifestations were of secondary importance.

In this country, White, Cobb and their associates[12, 13] made extensive observations on cases of neurocirculatory asthenia at the Massachusetts General Hospital, in collaboration with the Harvard Fatigue Laboratory. For the purpose of investigation, they regarded as of practical importance the separation of the acute from the chronic type and confined their studies to instances of the latter variety. Only preliminary reports have been published to date, but a number of facts were established. Men with this disorder were not able to do hard work as well as healthy soldiers. Their pulse rate recovery after exercise was slower and the rise in pulse was higher. Lactic acid determinations, taken after a walk of ten minutes on a treadmill, showed a level almost twice as high in patients as in normals. The ventilation index, which is an objective measurement correlated with the subjective feeling of dyspnea, was higher in patients than in the controls. The group with neurocirculatory asthenia showed looped capillary forms in the nail folds whereas in normal persons the hair-pin type predominated. Psychological tests yielded lower scores in those with neurocirculatory asthenia. Attempts to train a selected group under the supervision of an athletic director were unsuccessful. It was concluded, tentatively, that the chronic form of neurocirculatory asthenia is not a simple disturbance of the circulation but is associated with measurable psychological symptoms, abnormal behavior and difficulty in adjusting to life situations. There was evidence, also, of a familial incidence.

Still another approach was made by Starr,[14] using the ballistocardiogram as an indicator. This is a record of the forces generated by

the recoil of the heart and the impacts of the blood. From it can be calculated the cardiac output. The result is not highly accurate, but there appears to be a fairly definite range of normal. It was found that most of the subjects with neurocirculatory asthenia had abnormally large impacts. Starr was not inclined to agree with the notion that the condition is a neurosis, although admitting the possible accessory role of psychic disturbances. He drew the analogy between neurocirculatory asthenia and the common clumsiness of a muscular movement which might date from early life and was perhaps hereditary. Neurocirculatory asthenia, he suggested, might be thought of as a clumsiness of the circulation, with inability to adapt it to the needs of the moment.

Coronary Heart Disease. Fatal coronary arteriosclerosis in soldiers, 20 to 36 years of age, was the subject of a study by French and Dock.[15] Eighty cases examined at autopsy furnished the basis for their conclusions. The disease occurred in men of various racial stocks, without predilection for any particular one. The most common predisposing factor appeared to be overweight, which was present in 91 per cent of the patients. Vigorous effort and the activity of early morning chores brought on the attacks in over 50 per cent. Cardiac hypertrophy of significant degree did not occur in this series. Myocardial scars, indicating previous insults, were observed in 59 per cent of the cases and recent myocardial infarction was found in 19 per cent.

The direct relationship of effort to attacks of acute myocardial infarction in soldiers was further stressed by Blumgart,[16] who reported eleven cases. The matter is of practical importance as well as of theoretical interest. It appears to be true that the majority of attacks of coronary occlusion occur at rest; but this does not preclude the possibility that, in certain instances, exertion may be the initiating factor. There is good evidence, in civilian experience, that this is so.

Quinidine. Before the war, most of the quinidine used in this country came from Java. The supply was abruptly cut off when the Japanese took over the island and the available stock has steadily dwindled. Cinchona bark, obtained from South America, yields comparatively little quinidine. Since this drug is useful in a number of cardiac disorders and may be lifesaving in the treatment of ventricular tachycardia, it became necessary to seek a substitute. Under the auspices of the Subcommittee on Cardiovascular Diseases of the National Research Council, comparative tests are now being made, in patients, of the therapeutic

efficacy of commercial quinidine, synthetic quinidine and dihydroquinidine. Preliminary observations indicate that all three, in proper doses, produce similar clinical effects. The final results are not yet available, but should prove of practical value in the future.

Selective Service Examinations. The numerical importance of diseases of the heart and circulation, in men of draft age, became clearly evident in the figures published in 1942 by the Selective Service System.[17] Following the examination of the first million registrants, 18 to 37 years of age, it was estimated that 10.6 per cent were unqualified for general military service for cardiovascular reasons. Only defects of the teeth and eyes were responsible for a larger number of rejections. In 1944, after examination of 4,049,000 registrants of similar age groups, 58 per cent were disqualified for physical defects.[18] Of these, 6.5 per cent were rejected because of cardiovascular diseases.

Reexamination of Cardiac Rejectees. Because these rates seemed excessive for the age period covered, it was suggested by the Subcommittee on Cardiovascular Diseases of the National Research Council that one thousand men rejected for cardiovascular reasons be reexamined in each of five cities by boards of cardiologists. The plan was promptly approved by Major General Lewis B. Hershey, Director of the Selective Service System. Boston, Chicago, New York, Philadelphia and San Francisco were designated as the places in which the pilot tests should be made, because they could be carried out in large general hospitals with adequate facilities. The objects of the study were first, to obtain a more detailed analysis of problems of cardiovascular diagnosis and to define more clearly the range of the normal heart; second, to determine the possible amount of salvage of men for military service; and third, to compare the opinions of cardiovascular experts with those of examiners in the local boards and induction stations. In addition to the usual history and physical examination, an electrocardiogram and 2-meter film of the heart were taken in every case considered suitable for reclassification as 1A. The final analysis was based on the reexamination of 4,994 men.[19]

The following is a brief summary of the results:

1. Of the total number, 17 per cent were resubmitted as suitable for Class 1A; 83 per cent were confirmed as belonging to Class 4F.

2. The chief cause for final rejection was rheumatic heart disease, which was found in 60 per cent of the final 4F group. Mitral disease was

more common than that of the aortic valve. Auricular fibrillation, complicating mitral stenosis, was observed in only 24 cases.

3. The second most common cause for rejection was hypertension, which was found in 26 per cent. The majority showed elevation of both systolic and diastolic levels. The incidence was higher in the fourth than in the third decade.

4. Responsible for the rejection of between 4 and 5 per cent were, in order, neurocirculatory asthenia, sinus tachycardia and congenital heart disease. In the congenital group, the most frequent diagnosis was ventricular septal defect, which was present in more than a third of the cases. Next came patent ductus arteriosus, pulmonary stenosis (two with the tetralogy of Fallot), coarctation of the aorta, auricular septal defect and subaortic stenosis.

5. Other less common causes for rejection included cardiac enlargement alone, as determined by x-ray examination; and arrhythmia, including paroxysmal tachycardia, uncomplicated auricular fibrillation, auricular flutter and auriculoventricular block. Electrocardiographic abnormalities alone were found in 32 cases, including 10 with bundle branch block. Cardiovascular syphilis was rare, having been found in 17 cases. The diagnosis of coronary heart disease was made in only 6 cases.

6. A history of rheumatic fever was found in a little over one-fourth of all the cases of rheumatic heart disease. This figure was based on data obtained in four of the cities. However, a positive history was noted in nearly half of those in Boston and New York. A history of chorea was rare, having been obtained in only 2 per cent of the rheumatic cardiac cases.

7. Nine of the seventeen cases of aortic syphilis were observed in negroes. Hypertension was more common in the black race. Rheumatic heart disease was evenly represented among whites and blacks, but neurocirculatory asthenia was infrequent in the negroes.

As a result of these examinations, it was concluded that their extension for the sake of salvage alone was of doubtful value because of the time required, the few expert examiners available and the relatively small percentage of men reclassified as 1A. But some of the lessons learned proved helpful in later examinations; and the uncertainty concerning the significance of transient hypertension stimulated the series of "Studies of Blood Pressure in Army Officers," to which reference will be made shortly.

A follow-up study of the men reclassified as 1A has been initiated and will be completed with the help of the Veterans' Administration. In these cases there was a difference of opinion between the special boards appointed for the reexamination study and the local boards or induction stations, which had rejected them. The after histories of this group of border-line cases finally accepted for service, should prove instructive.

Effectiveness of Selective Service Examinations. Three reports have been chosen to illustrate this point. The first was from the Medical Processing Unit and the Station Hospital at the San Antonio Aviation Cadet Center.[20] During a number of months, approximately 45,000 men, between 18 and 27 years of age, were examined. Only 100 were found to have rheumatic valvular disease and of this group, 11 knew of the presence of a heart murmur when in civilian life. This is an incidence of approximately 0.2 per cent. The most common lesion was aortic regurgitation; mitral stenosis was second in the order of frequency.

Another report, from the Navy,[21] was based on the experience of a hospital ship in which there were 9,085 admissions and that of a base hospital in which there were 13,000 admissions. On the ship, 55 patients were found to be suffering from valvular heart disease, degenerative heart disease or functional cardiac disorders; this is an incidence of 0.6 per cent. In the base hospital, 88 patients were found to be suffering from cardiac disorders—an incidence of 0.67 per cent. Sprague and McGinn, who made this study, were impressed by the relative infrequency of neurocirculatory asthenia.

The third report was a summary of the Army's experience with discharges of enlisted men for physical reasons.[22] During the 12 months between July, 1943 and June, 1944, 6.5 per cent of discharges were for cardiovascular diseases. This group was fifth on the list, in which neuropsychiatric disorders led by a wide margin. Cardiovascular diseases appeared to be more common among men who had not been overseas. This was not surprising, for rheumatic fever in the camps at home undoubtedly was responsible for many of these cases; and most of those with cardiac lesions were eliminated during the training period, so that they were not sent out of the country.

Studies of Blood Pressure in Army Officers. The range of the normal blood pressure, both systolic and diastolic, is still not clearly defined. Transient hypertension, due to emotion or some other cause not apparent, has been recognized but discounted by the Army. In Mobilization

Regulations 1-9, issued by the War Department in 1942, it is stated that "if the blood pressure appears to be abnormally high, it will be measured after the subject has rested in the recumbent position." A cause for rejection is "a persistent blood pressure at rest above 150 mm. systolic or above 90 diastolic unless, in the opinion of the medical examiner, the increased blood pressure is due to psychic reaction and not secondary to renal or other systemic disease." "Elevation of blood pressure from excitement proved to be temporary," is not a cause for disqualification. Because of the large number of recruits who showed such temporary elevations, it seemed important to determine their significance as soon as possible.

The records of some 23,000 Army officers on file in the Office of the Surgeon General furnished a ready material. These contained the results of annual physical examinations made between January, 1924 and December, 1941; in more than 1,800, additional information was obtained as far back as 1901. Annual examinations were discontinued in 1941, owing to the pressure of work essential to the war.

A contract was recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Columbia University, and the work of analysis was undertaken by Drs. Levy, Stroud and White of the Subcommittee on Cardiovascular Diseases of the National Research Council, in collaboration with Brigadier General Charles C. Hillman, U. S. Army. Dr. John W. Fertig, Professor of Biostatistics, Columbia University College of Physicians and Surgeons, aided in the analysis and preparation of the material for final presentation. The method of person-years was used in calculating the results.

A total of 22,741 cases proved to be suitable for study.[23] The average length of the observation period was 12 years. Seventy-two per cent were under observation from 5 to 19 years and 38 per cent were observed from 15 to 19 years. In 1,437 cases, or 6 per cent of the total, the observation period was 20 years or over. The specific indexes chosen to demonstrate the influence of transient hypertension on the subsequent state of health and cause of death were: (1) the later development of sustained hypertension; (2) the disability retirement rates with cardiovascular-renal diseases; and (3) the death rates with cardiovascular-renal diseases.[24]

The frequency with which transient hypertension was first noted

increased with age. The curve of increase was smooth, beginning with an incidence of 6 per cent in the age group 25 to 29 and reaching a plateau of 19 per cent at 50 to 54. At all ages, sustained hypertension developed more frequently in those with previous transient hypertension than in those who never showed an elevation of blood pressure. In both groups, the rate increased with advancing years.

The rate for disability retirement with cardiovascular-renal diseases, which is one index of the usefulness of an officer to the Army, was consistently higher in those with previous transient hypertension than in those with normal pressure levels, at all ages from 35 to 60. The death rate was also higher in those with transient hypertension and the figures rose in the older age groups.

In the study just mentioned, the group with transient hypertension was dealt with as a whole and no attempt was made to ascertain possible differences in the prognostic importance of various systolic and diastolic levels. To obtain data on this point seemed the next logical step in the inquiry.[25] It was found that all levels of transient hypertension, both systolic and diastolic, were significant in terms of the later development of sustained hypertension and retirement with cardiovascular-renal diseases. Of particular interest was the observation that slight degrees of elevation were important, even when the systolic level alone was involved. Of the greatest significance, however, was a transient rise in diastolic pressure above 100 mm., especially as an early sign of subsequent sustained hypertension.

No significant differences were apparent between the various degrees of transient hypertension in relation to the death rates with cardiovascular-renal diseases. Thus, a temporary rise in blood pressure does not appear to foretell the rate of progress of vascular disease or the extent or severity of the lesions which eventually cause death.

These data lend support to the view that transient elevations of blood pressure, above the upper range of normal, often represent an early stage of hypertensive vascular disease.

Many of the registrants with transient hypertension also showed transient tachycardia. By transient tachycardia is meant a pulse rate of 100 or over, which is not persistent and not due to paroxysmal tachycardia. Army Regulations provide that a candidate is not acceptable who shows "a persistent heart rate of 100 or over when this is proved to be persistent in the recumbent posture and on observation and reexamina-

tion over a sufficient period of time."

The groups of cardiologists who made the reexaminations of the 5,000 rejectees, were not impressed by the importance of a temporary increase in heart rate. In fact, in the report of the study, the question was raised as to the advisability of extending the upper limit of normal from 100 to 120 beats per minute. Because of the lack of precise information concerning the significance of transient tachycardia in terms of the subsequent history, the same medical records of 22,741 Army officers were analyzed with transient tachycardia as the topic of central interest. The same indexes for prognosis were employed.[26]

As in the case of transient hypertension, the frequency of transient tachycardia increased somewhat with age, up to 45; at this point, a plateau apparently was reached. The frequency, however, was considerably less than that found for transient hypertension. The group with transient tachycardia showed higher rates for later sustained hypertension and for retirement with cardiovascular-renal diseases than did the control group. The rates were similar to those for the group with transient hypertension.

The death rate with cardiovascular-renal diseases in the group with transient tachycardia was not significantly greater than in the controls. This was in contrast to the group with transient hypertension, in which a significant increase was shown. This discrepancy may have been due, in part, to the fact that the number of deaths involved was small.

When both transient tachycardia and transient hypertension were present, the incidence of later sustained hypertension was more than twice as great as when either condition was present alone. The incidence of retirements and deaths with cardiovascular-renal diseases was also higher, but to a less marked degree.

It was concluded that transient tachycardia due to emotional disturbance or some other cause not discernible, like transient hypertension of similar origin, is often a precursor of hypertensive vascular disease. In this respect, the two conditions are of equal importance.

It seems probable that the facts pertaining to transient hypertension and transient tachycardia, which have been derived from an analysis of the records of army officers, apply also to the general male population of comparable physical fitness and similar age groups. Work with this material is still in progress and other aspects of the study will be reported in subsequent papers.

Conclusion

It is apparent, from this sketchy survey, that many of the clinical problems of military cardiology are closely related to those of civilian life. They differ in being of urgent concern to many persons. In a national emergency, those best qualified willingly concentrate their efforts on tasks of immediate importance. Experience is accumulated rapidly, for results must be obtained with speed. It is well to remember that accelerated accomplishment is possible, in great measure, because of training previously acquired, because of foundations laid by work already done, and because necessary techniques are at hand. In the basic sciences, as indicated in the recent report of Vannevar Bush,[27] it is questionable whether such coördinated and hurried research, in the long run, promotes progress. To clinical medicine, on the other hand, a special opportunity is presented. A large and varied human material is available for intensive study. Conditions can be controlled to an unusual degree. To the investigators in each field every facility is afforded. In this opportunity, cardiology has been permitted to share.

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